BASIC RESEARCH STUDIES

From the Society for Vascular Surgery

The development of endotension is associated with increased transmission of pressure and serous components in porous expanded polytetrafluoroethylene stent-grafts: Characterization using a canine model

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Objective: **This study used a canine model of abdominal aortic aneurysms (AAAs) to compare intra-aneurysmal pressure and thrombus formation after exclusion with Dacron and expanded polytetrafluoroethylene (ePTFE) stent-grafts.**
Methods: **Prosthetic AAAs with implanted strain-gauge pressure transducers were treated by stent-graft exclusion using Food and Drug Administration-approved devices in 10 mongrel dogs: five Dacron (AneuRx) and five ePTFE (original Excluder). Intra-aneurysmal pressure was measured over 4 weeks after AAA exclusion and indexed to the systemic pressure, represented as a percentage of a simultaneously obtained systemic pressure (value = 1.0). Magnetic resonance imaging (MRI) of the intra-aneurysmal thrombus was performed at 1, 2, and 4 weeks after exclusion and expressed as a signal-to-noise ratio (S:N) to control for background signal intensity. Comparisons of pressures and S:N between the two stent-grafts was analyzed with the Student's *t* test. Intra-aneurysmal thrombus was characterized histologically.**
Results: **In animals excluded with both Dacron and ePTFE stent-grafts, the intra-aneurysmal pressure was nonpulsatile and reduced to <30% of systemic pressure. Significantly greater pressure transmission was observed after AAA exclusion using ePTFE compared with Dacron stent grafts (systolic pressure: ePTFE, 0.28 ± 0.12 vs Dacron, 0.11 ± 0.02, $P < .001$; mean pressure: ePTFE, 0.16 ± 0.08 vs Dacron, 0.06 ± 0.02, $P < .001$). MRI confirmed the absence of perfusion in all aneurysms. The T1-weighted signal intensity remained persistently elevated (S:N at 1 week, 2.7 ± 0.4 vs 2 weeks, 4.0 ± 0.2 vs 4 weeks, 5.4 ± 1.3) in ePTFE-treated intra-aneurysmal thrombus, suggesting an absence of thrombus organization. In contrast, progressive evolution of T1 signal intensity in aneurysms excluded by Dacron stent-grafts was consistent with maturation from intact red blood cells (S:N at 1 week, 3.3 ± 0.4) to methemoglobin (S:N at 2 weeks, 6.1 ± 0.8), and then hemosiderin and ferritin (S:N at 4 weeks, 2.4 ± 0.5). Histologically, ePTFE-excluded aneurysms contained poorly organized thrombus with red blood cell fragments and haphazardly arranged fibrin deposition indicative of active remodeling and continued influx of transudated serum. In aneurysms excluded by Dacron stent-grafts, dense, mature collagenous connective tissue and organized fibrin were present, indicative of greater thrombus organization.**
Conclusions: **Stent-graft treatment reduces intra-aneurysmal pressure to <30% of systemic pressure when no endoleak is present; however, significantly greater pressure is present in aneurysms treated with porous ePTFE stent-grafts than Dacron grafts. Histologic and MRI imaging analysis suggest that active transudation of serous blood components may be contributing to this increased intra-aneurysmal pressure. (J Vasc Surg 2006;43:109-16.)**

Clinical Relevance: **Continued expansion of abdominal aortic aneurysms (AAAs) in the absence of an endoleak after endovascular repair is thought to result from endotension. Clinical studies have shown that AAAs excluded with grafts made from expanded polytetrafluoroethylene (ePTFE) are more likely to result in aneurysm sac expansion, which may be the result of transudation of serous blood components through the stent-graft. This study used an animal model of AAA to examine aneurysm sac pressure and resulting thrombus in abdominal aortic aneurysms treated with either ePTFE or Dacron stent-grafts.**

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Endovascular stent-grafts are used to treat abdominal aortic aneurysms (AAAs) by excluding the aneurysm sac from arterial circulation. Endotension has been proposed to account for the continued expansion of the aneurysm sac after endovascular repair in the absence of perfusion or endoleak.[1] This is associated with a nonpulsatile pressure that is approximately one third of systemic pressure. Preliminary clinical data suggest that stent-grafts constructed from expanded polytetrafluoroethylene (ePTFE) may result in continued expansion of the AAA, despite complete exclusion of the aneurysm from the arterial circulation as evidenced by the absence of an endoleak.[2-4] In addition, aneurysm sac hygromas, with the appearance of a gelatinous sac content, have been described with ePTFE grafts in several case reports.[5-7] This study sought to compare intra-aneurysmal pressure and content after exclusion with United States Food and Drug Administration (FDA)-approved Dacron or ePTFE stent-grafts in a canine model of AAA.

METHODS

Prosthetic AAAs with implanted strain-gauge pressure transducers were treated by stent-graft exclusion using FDA-approved devices in 10 mongrel dogs: five Dacron AneuRx (AAA Stent-Graft System, Medtronic, Santa Rosa, Calif) and five porous ePTFE original Excluder (WL Gore and Assoc, Flagstaff, Ariz). Each of the dogs weighed 25 to 35 kg. The procedures and handling of the animals were reviewed and approved by the Institutional Animal Care and Use Committee at Weill Medical College of Cornell University. All procedures were in accordance with the *Guide for the Care and Use of Laboratory Animals* by the Institute of Laboratory Animal Resources, Commission on Life Sciences.[8]

Pressure transducer and prosthetic aneurysm creation. An implantable, solid-state, strain-gauge pressure transducer (Konigsberg Instruments, Pasadena, Calif) was used for daily monitoring of systemic and intra-aneurysmal pressure. The accuracy of the transducer has been confirmed in various media in vitro and in vivo, including liquid, gelatinous, and solid environments.[9,10] Continuous pressure monitoring and data storage were performed by using data recording software from Data Integrated Scientific Systems (DISS, Detroit, Mich). Before implantation and after explantation, calibration of the transducer was preformed. Daily systemic and intra-aneurysmal pressures were taken for 4 weeks after aneurysm creation and exclusion. The intra-aneurysmal pressure was indexed to the systemic pressure, which was obtained simultaneously; therefore, an index pressure of 0.28 represents 28% of the systemic pressure.

Balloon dilation was used to create the prosthetic aneurysm from thin-walled PTFE (8-mm-diameter Impra, Bard Peripheral Vascular, Tempe, Ariz) before implantation. The final diameter of the prosthetic aneurysm was 30 mm. The pressure transducer was approximated to the luminal surface of the prosthetic aneurysm and secured in place (Fig 1).

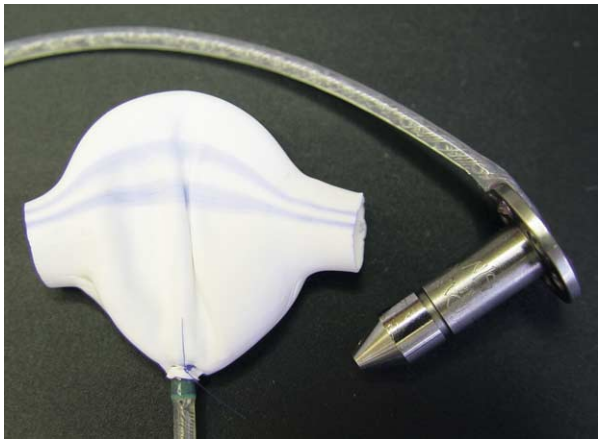

Fig 1. An expanded polytetrafluoroethylene aneurysm with an implanted pressure transducer. The transducer cable is tunneled through the abdominal wall and tracked subcutaneously toward the dorsal aspect of the animal. The metal connector exits the interscapular skin, caudal to the neck. This allows continuous intra-aneurysmal pressure measurement.

Implantation of prosthetic aneurysm and pressure transducers. The animals were fasted overnight and on the day of surgery were anesthetized (induction, thiopental 8 mg/kg; maintenance, isoflurane 2%), intubated, and ventilated. The abdominal aorta from the level of the renal arteries to the trifurcation was exposed via a midline abdominal incision. After obtaining proximal and distal control, the aorta was completely transected. The prosthetic 30-mm-diameter aneurysm containing an intraluminal strain-gauge pressure transducer was sewn to the transected ends of the aorta as an interposition graft (Fig 2). A second strain-gauge pressure transducer was placed in the native aorta proximal to the aneurysm. Systemic anticoagulation with unfractionated sodium heparin (2000 U intravenously) was maintained throughout the period of arterial clamping.

Exclusion of the aneurysm. Aneurysm exclusion was performed during the same procedure (Fig 3) via the midline laparotomy incision by using one of two different stent-grafts (Dacron, five animals; ePTFE, five animals). Exclusion was performed via the midline laparotomy incision because the delivery system (16F) for the stent-grafts is larger than the canine femoral artery. The FDA-approved Dacron stent-graft used in this study was the AneuRx AAA Stent Graft System (iliac limb, resilient high-density graft material), which consists of an exoskeleton of nitinol over a polyethylene terephthalate (Dacron) graft material. The Dacron stent-graft porosity is defined by its water integral permeability of 211 ± 26 mL/min/cm^2, which is the standard method for measuring the porosity of industrial fabrics such as Dacron. The FDA-approved ePTFE stent graft utilized in this study was the original Excluder (original high porosity) made of nitinol-covered ePTFE. Because ePTFE is hydrophobic, the water integral permeability is not a reliable measurement of its porosity; therefore, ex-

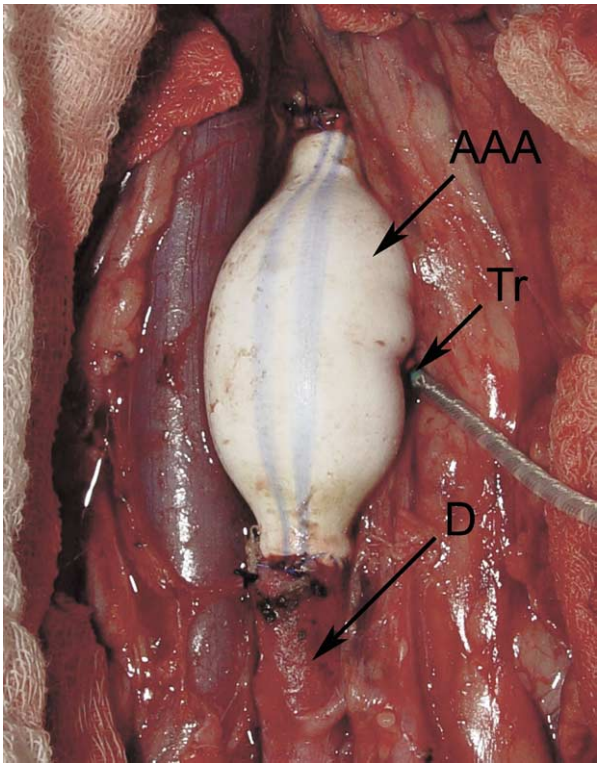

Fig 2. The appearance of a prosthetic infrarenal aneurysm *(AAA)* in situ. The cable of the pressure transducer *(Tr)* is seen at the right side of the image as it exits the wall of the aneurysm. Trifurcation is beyond the distal aspect *(D)* of the aorta shown in the photo.

truded materials such as ePTFE are characterized by their internodal distance, which for the original Excluder is 25 μm.

The dogs were randomized to receive one of the two grafts before the start of each surgery. In five animals, a Dacron stent-graft (12-mm diameter × 5.5-cm length) was deployed, and in five animals an ePTFE stent-graft (12-mm diameter × 7-cm length) was deployed. All stent-grafts were introduced through the distal aorta, with a sheath being used for the ePTFE stent graft and no sheath for the AneuRx stent-graft. The additional length of this stent-graft was placed in the native vessels, creating a hemostatic seal in all cases. The degree of oversizing was equal in both stent-grafts, and postdeployment angioplasty with 8-mm balloons was done in all cases. Intraoperative angiography with multiple oblique projections was performed in all cases after stent-graft deployment to confirm the integrity of the exclusion from antegrade perfusion (Fig 4). In addition, flush aortography was performed 4 weeks after stent graft exclusion (before sacrifice) to confirm absence of endoleaks.

The peritoneal cavity was closed, and the cables from the pressure transducers were tunneled laterally through the abdominal wall and tracked subcutaneously to exit the skin between the scapulae. The animals were extubated and allowed to recover overnight. All animals received clopidogrel (75 mg/day) (Sanofi-Synthelabo Pharmaceuticals, New York, NY) starting the day of surgery and continuing until euthanasia.

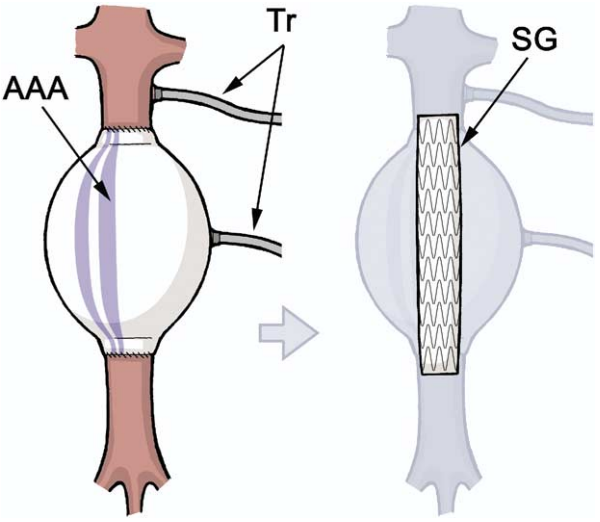

Fig 3. Schematic illustration of prosthetic aneurysm. **A,** Dilated segment of polytetrafluoroethylene (PTFE) is inserted as an interposition graft within the transected infrarenal aorta to create an abdominal aortic aneurysm *(AAA)*. A strain-gauge pressure transducer *(Tr)* allows intra-aneurysmal pressure determination. **B,** The aneurysm is excluded with a PTFE or Dacron stent-graft *(SG)*.

Magnetic resonance imaging. Before magnetic resonance imaging (MRI), the animals were premedicated, anesthetized, intubated, and mechanically ventilated in a manner similar to preparation for operative procedures. T1-weighted MRI images and gadolinium-enhanced magnetic resonance angiography (MRA) images were obtained by using a fast spoiled gradient-recalled protocol in a 3.0 Tesla MRI system (GE Medical Systems, Waukesha, Wis) at 1, 2, and 4 weeks after aneurysm exclusion. Post processing with GEMS 4.0 Fiesta video imaging software (GE Medical Systems) was used to analyze the images (Fig 5).

A localizer scan was obtained in the coronal, axial, and sagittal planes and was used to determine subsequent imaging in the axial plane for T1-weighted images and cine-gated MRA. T1-weighted images were obtained from the renal arteries to the abdominal aortic trifurcation by using double inversion recovery fast spin echo sequences. Parameters of T1-weighted images were TR, 350 milliseconds; TE, 14 milliseconds; FOV, 20 cm; and matrix, 256 × 256. The T1-weighted images were used to analyze the characteristics of the thrombus, quantified by determining the signal-to-noise ratio (S:N). The S:N was calculating as the ratio of the signal in the area of the thrombus compared with the signal intensity of the air in the same image, allowing a standardization of the MRI signal intensity (Fig 5) This well-established technique helps eliminate interexamination variability. A radiologist blinded to the histologic results determined the signal intensity of the thrombus in at least three different sections for each time point.

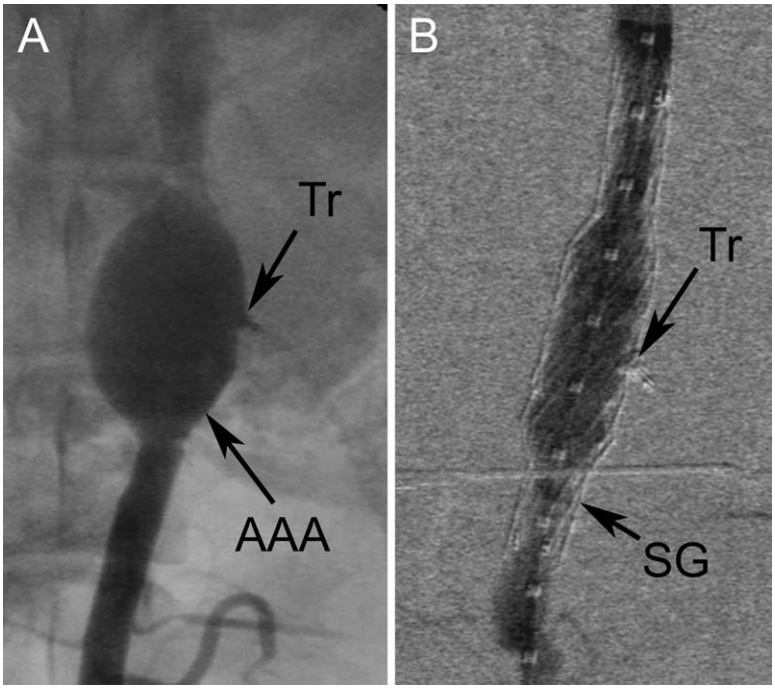

Fig 4. Intraoperative angiography used during endovascular exclusion of aneurysms. **A,** An angiogram demonstrates the prosthetic aneurysm *(AAA)* with an indwelling strain-gauge transducer *(Tr)*. **B,** Digital-subtraction angiogram demonstrates the use of an endoluminal aortic stent-graft *(SG)* to exclude the same aneurysm.

Euthanasia. Animals were euthanized 30 days after aneurysm exclusion via an injection of Sleepaway (Ft Dodge Laboratories, Ft Dodge, Iowa).

Histology. The aneurysm was perfusion-fixed in 3% glutaraldehyde buffered to pH 7.4 with sodium cacodylate for histopathologic investigation. The aorta was divided longitudinally to remove the stent-graft before paraffin embedding. Transverse, longitudinal, and oblique sections of the aneurysm content were embedded in paraffin. Intra-aneurysmal thrombus was characterized histologically using hematoxylin and eosin, Masson's trichrome, and Mallory's phosphotungstic acid hematoxylin (PTAH) stains. Masson's trichrome was used to detect collagen, which is labelled blue, and PTAH was used to identify fibrin, labelled purple.

Statistics. Intra-aneurysmal pressure measurements were indexed to the systemic pressure, which was obtained simultaneously. The intra-aneurysmal pressure is represented as a percentage of the systemic pressure, with the systemic pressure having a value of 1.0. Results are represented as the mean ± standard deviation. Continuous variables were analyzed using the Student's *t* test, with statistical significance assumed at $P \leq .05$. All statistical analysis was performed with SPSS (version 10) (SPSS, Chicago, Ill) for Windows (Microsoft, Redmond, Wash).

RESULTS

Complete exclusion from antegrade perfusion was achieved in all animals. No endoleaks were present, which was confirmed by MRI throughout the study and on angiography at the time of euthanasia. In animals excluded with both Dacron and ePTFE stent-grafts, the sac pressure was nonpulsatile and reduced to <30% of systemic pressure (Table I). In aneurysms excluded with ePTFE stent-grafts, the systolic pressure within the aneurysm sac after exclusion was reduced to 0.28 ± 0.12 compared with 1.0 for systemic pressure. Aneurysms excluded with Dacron stent-grafts had a significantly lower intra-aneurysmal sac systolic pressure of 0.11 ± 0.02 (1.0 for systemic pressure compared with ePTFE stent-grafts, $P < .0001$).

The mean intra-aneurysmal pressure followed a similar pattern. In aneurysms excluded with ePTFE stent-grafts, mean intra-aneurysmal pressure was reduced to 0.16 ± 0.08 of the mean systemic pressure (1.0). The mean intra-aneurysmal pressure in dogs treated with Dacron stent-grafts was significantly less, reduced to 0.06 ± 0.02 compared with 1.0 for the mean systemic pressure ($P < .0001$).

Analysis of the MRI T1-weighted signal intensity of AAAs excluded by ePTFE stent-grafts continued to increase for the duration of the study for up to 4 weeks. The mean S:N of AAAs excluded by ePTFE stent-grafts was initially 2.7 ± 0.4, increasing to 4.0 ± 0.2 and 5.4 ± 1.3 at 1, 2, and 4 weeks, respectively (Table II). This contrasted with the T1-weighted signal intensity of AAAs excluded with Dacron stent-grafts, which initially had a mean S:N of 3.3 ± 0.4 at 1 week, peaked at 2 weeks to a mean S:N of

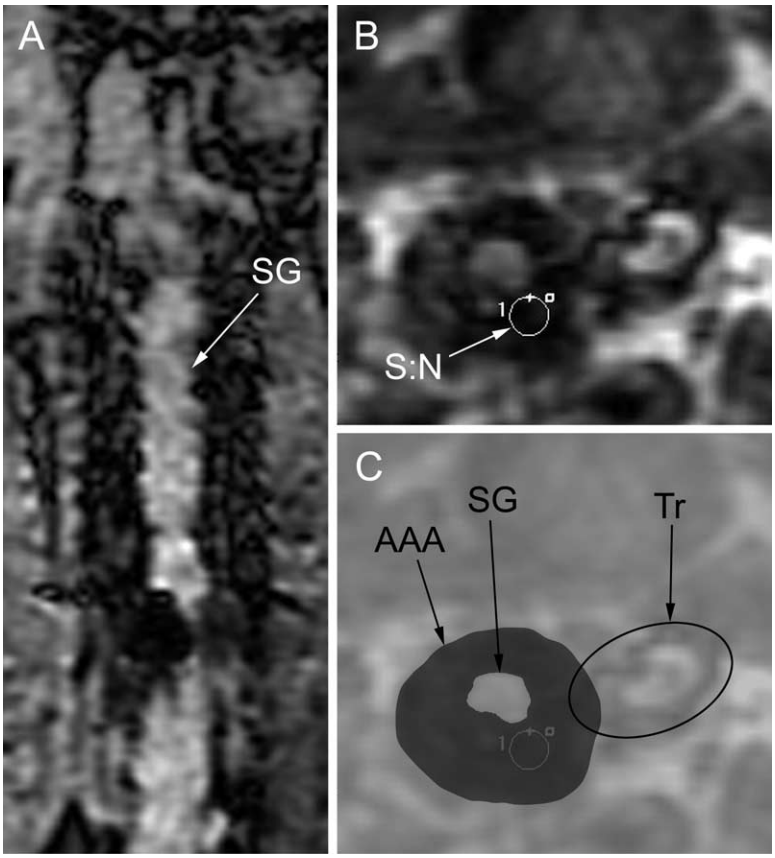

Fig 5. A, Magnetic resonance angiography with gadolinium demonstrates aneurysm (AAA) after endovascular exclusion with a stent-graft *(SG)*. **B,** T1-weighted magnetic resonance axial image demonstrates acquisition of signal intensity *(S:N)* from the AAA sac. The area of high intensity represents the lumen of the stent-graft. **C,** Schematic of the magnetic resonance axial image demonstrates the stent-graft *(SG)* and the aneurysm sac *(AAA)* with pressure transducer *(TR)* exiting from the aneurysm sac.

Table I. Intra-aneurysmal pressure analyzed by type of stent-graft used to exclude the aneurysm

	*Systolic pressure**	*Mean pressure**
Dacron (AneuRx)	0.11 ± 0.02	0.06 ± 0.02
ePTFE (original excluder)	0.28 ± 0.12	0.16 ± 0.08
Systemic pressure	1.0	1.0
$P^{\dagger}$	<.0001	<.0001

ePTFE, Expanded polytetrafluoroethylene.
*All pressures listed were after endovascular exclusion and are indexed as a percentage of systemic pressure.
†Student's *t* test.

Table II. Changing magnetic resonance imaging signal intensity over time after endovascular exclusion of abdominal aortic aneurysms with stent grafts made either of Dacron or ePTFE

	Type of stent-graft		
*Time**	*Dacron*	*ePTFE*	P†
1 week	3.3 ± 0.4	2.7 ± 0.4	.02
2 weeks	6.1 ± 0.8	4.0 ± 0.2	<.001
4 weeks	2.4 ± 0.5	5.4 ± 1.3	<.001

ePTFE, Expanded polytetrafluoroethylene.
*Time after endovascular exclusion.
†Student's *t* test.

6.1 ± 0.8, and then declined to a mean S:N of 2.4 ± 0.5 at 4 weeks.

The progressive evolution of the signal intensity in aneurysms excluded with Dacron stent-grafts is suggestive of maturation of the thrombus from intact red blood cells to methemoglobin and eventually to hemosiderin and ferritin, as has been observed in previous studies performed with this model. The persistent elevation of the T1-weighted signal intensity in ePTFE-treated AAAs suggests active thrombus remodeling and an absence of thrombus organization.

Histologic analysis confirmed the MRI findings. For all animals, histology was uniform throughout the AAA sac, including the interface of the thrombus and the stent-graft. AAAs excluded by ePTFE stent-grafts resulted in an acute

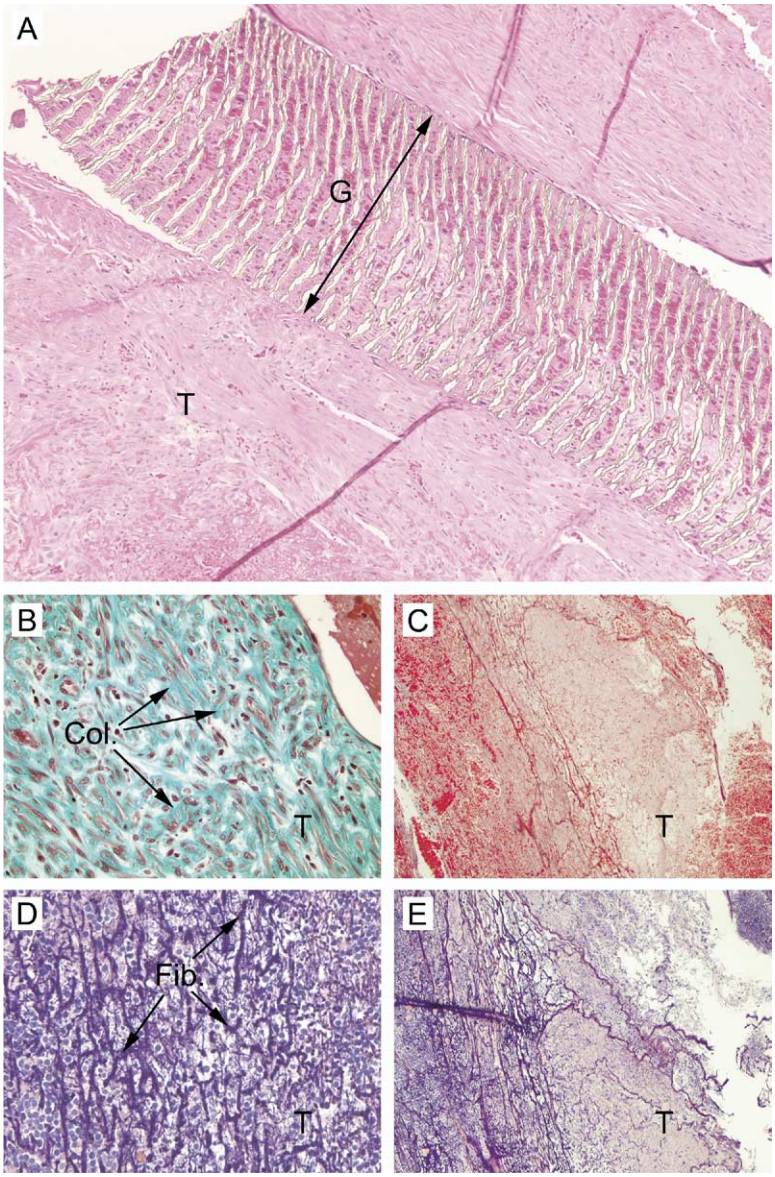

Fig 6. Comparison of histology of aneurysm sacs removed from canines with prosthetic aneurysms 4 weeks after endovascular treatment with either expanded polytetrafluoroethylene (ePTFE) or Dacron stent-grafts. Throughout pictures, *T* represents thrombus, *G* represents prosthetic aneurysm; *Fib*, fibrin, and *Col*, collagen. **A,** Hematoxylin and eosin staining of tissue demonstrates overview of the histology of aneurysm sac contents and prosthetic aneurysm sac wall 4 weeks after exclusion with a Dacron stent-graft (×4). **B,** Masson's trichrome staining for collagen *(arrow)* demonstrates chronic thrombus in abdominal aortic aneurysm (AAA) sac after exclusion by a Dacron stent-graft (×40). **C,** Masson's trichrome staining for collagen demonstrates lack of collagen, indicated by absence of blue labeling in AAA sac after exclusion by an ePTFE stent-graft (×10). **D,** Mallory's phosphotungstic acid hematoxylin staining (PTAH) for fibrin of aneurysm sac and contents demonstrates well-organized fibrin in thrombus of AAA sac after exclusion by a Dacron stent-graft (×20). PTAH staining for fibrin demonstrates disorganized, limited fibrin in thrombus of an AAA sac after exclusion by a Dacron stent-graft (×10).

fibrin thrombus in the excluded aneurysm sac. Trichrome staining demonstrated the absence of either collagen or granulation tissue. The thrombus was poorly organized, with red blood cell fragments and haphazardly arranged PTAH-positive fibrin deposition indicative of active remodeling and continued influx of transudated serum (Fig 6).

In contrast, AAAs excluded by Dacron stent-grafts resulted in thrombi that were well organized and chronically composed mostly of granulation tissue. Trichrome staining confirmed the presence of dense, mature collagenous connective tissue, with hemosiderin and hematoidin deposition. The fibrin was well organized as demonstrated

with the PTAH stain (Fig 6). No seromas was seen external to the prosthetic (PTFE) aneurysm at the time of sacrifice.

DISCUSSION

The success of the endovascular treatment of AAAs is based on the elimination of arterial perfusion from the aneurysm sac. In animals excluded with both Dacron and ePTFE stent-grafts, the intra-aneurysmal pressure was nonpulsatile and reduced to <30% of systemic pressure, with significantly greater pressure present in aneurysms treated with porous ePTFE stent-grafts compared with Dacron stent-grafts. Aneurysms excluded with ePTFE stent-grafts resulted in sac thrombi that suggested active thrombus remodeling, whereas sac thrombi in AAAs excluded with Dacron stent-grafts were made of connective tissue, suggesting chronic thrombus.

The findings of this present study support what has been observed in the clinical setting. Device-specific outcomes after endovascular AAA repair have been evaluated in multiple studies. In one study comparing six devices, the original porous Excluder device was associated with the lowest rate of aneurysm size reduction at 36 months of follow-up.[2] In the multicenter trial of the original Excluder, only 19% of patients had AAA sac regression, whereas 14% had AAA sac enlargement at 2 years.[3] A single-institute study of patients treated with the original Excluder found that the probability of freedom from sac growth or re-expansion at 4 years was only 43%.[4]

AAA sac hygromas with the appearance of viscous, gelatinous sac content have been described with ePTFE grafts in several case reports after open and endovascular repair. The formation of these "seromas" around prosthetic (PTFE) grafts used for hemodialysis access and subclavian artery-pulmonary artery shunts has long been known and reported in the literature since the early 1980s.[11] Williams[11] described a 12-cm cystic mass filled with a seroma-like fluid surrounding a patent PTFE graft 2.5 years after open AAA repair and was one of the first to hypothesize ultrafiltration through the graft as a potential cause. Risberg et al[12] described three cases of aneurysm sac hygromas after repair of AAAs using PTFE grafts: two occurred after endovascular repair and one after open repair. Analysis of the fluid drained from these hygromas indicated activation of both the coagulation and fibrinolytic systems.[12] An aneurysm sac hygroma was discovered 18 months after thoracic endograft repair (ePTFE stent-graft) when the patient became dyspneic.[5] A rupture related to an hygroma was described in a case series of five patients with symptomatic sac enlargement after open AAA repair with PTFE grafts. During laparotomy, a seroma with gelatinous material was discovered that histologically revealed degenerate red blood cells and amorphous eosinophilic material.[6]

In this present study, AAAs excluded with ePTFE stent-grafts resulted in thrombi that histologically were consistent with an acute thrombus, with red blood cell fragments and disorganized fibrin, whereas the thrombi of AAAs excluded with Dacron stent-grafts were mostly composed of collagen or granulation tissue, consistent with a chronic thrombus. Although the level of organization at 4 weeks was less in ePTFE stent-grafts, given additional time, further organization may have occurred.

Thrombus formation in the aneurysm sac is influenced by stasis of blood that occurs after the aneurysm is excluded from antegrade flow. This stasis leads to fibrin deposition and also prevents the inflow of inhibitors of clotting factors, which helps to allow the formation of an organized thrombus. Without the inflow of fibrinolytic factors, the thrombus in the aneurysm sac is eventually converted into a subendothelial mass of connective tissue that can potentially recanalize.[13]

Magnetic resonance imaging has been used to help identify the stages of thrombus formation in both animal models and human disease. This knowledge is based on studies of acute cerebral hemorrhage that demonstrated the changing appearance of MRI signal intensity is secondary to the interactions of the molecules of hemoglobin degradation (oxyhemoglobin, deoxyhemoglobin, methemoglobin, ferritin, and hemosiderin) and the changing hydration state of the hemorrhage.[14] A swine model of acutely formed carotid thrombi found that the evolution of MRI appearance correlated to the histologic progression of the thrombus (red blood cells and fibrin → cellular debris → connective tissue → organized collagen). The study found that the MRI signal intensity demonstrated a rapid increase followed by a decline as thrombus became stable.[15]

In addition, previous work done on this canine model demonstrated that the changing MRI signal intensity corresponds to the evolution of the thrombus over time. In this present study, a similar pattern of increase in signal intensity followed by decline over time was seen in those aneurysms excluded with Dacron stent-grafts, whereas the signal intensity remained elevated in aneurysms excluded with ePTFE stent-grafts, which correlated with the different histologic findings.

AAAs excluded by ePTFE stent-grafts were found to have significantly higher aneurysm sac pressures than those that were excluded with Dacron stent-grafts, without any evidence of endoleaks. Endotension is proposed to account for continued aneurysm expansion after endovascular repair in the absence of aneurysm perfusion.[1] In a small case series, endotension was found to be a nonpulsatile sac pressure that was approximately one third of systemic pressure.[7] Potential causes of endotension include degradation of the aneurysm sac thrombus and ultrafiltration through the graft material.

Sjogren et al[16] postulated that the pressure in aneurysm sacs may trigger an upregulation of tissue plasminogen activator, increasing the fibrinolytic activity and resulting in the lysis of the thrombus. The increased pressure in the aneurysm sac from endotension has the potential to result in an increase in the aneurysm sac size, which in multiple studies has been seen to more commonly occur after repair with the original Excluder than grafts made of Dacron, including the AneuRx stent-graft.[2-4] Reports of rare ruptures after endograft repair have been associated with most stent-grafts and are usually secondary to fixation of the

aortic neck or iliac artery, or patient refusal to have treatment for known endoleaks.[17]

Graft material and porosity have significant implications regarding the endovascular repair of AAAs. The porosity of the prosthetic graft material is critical to its ability to create a hemostatic seal and prevent hemorrhage through the graft. Previous experimental research utilizing a canine model of AAA evaluated the effect of stent-graft porosity on pressure transmission to the aneurysm sac after treatment with an endovascular stent-graft.[10] In this previous study, nonporous stent-grafts were demonstrated to reduce pressure transmission to the aneurysm sac to <10% of systemic pressure. In contrast, the highly porous co-knit graft resulted in transmission of pressure that was 80% of systemic pressure.[18] Our study did not use any knitted Dacron grafts.

In this present study, the differences in porosity of the two stent-grafts evaluated are likely to be a significant factor in the increased pressure observed in the aneurysm sac of AAAs excluded with ePTFE stent-grafts. However, differences in the materials themselves may also contribute to these differences. Increased transudation of fluid through the ePTFE stent-graft may occur because of characteristics specific to the material. Normally, ePTFE is hydrophobic but may become "wettable" if exposed to certain agents such as Betadine (Purdue Frederick Co, Norwalk, Conn) or blood.[12] Finally, some studies have shown that transudation of fluid through PTFE may occur because of failure of the fibroblasts to incorporate the graft.[19]

CONCLUSION

In this animal model of AAA, we found that endovascular treatment with either Dacron or ePTFE stent-grafts reduces the mean intra-aneurysmal pressure to a nonpulsatile pressure that is <30% of systemic pressure. However, significantly greater pressure was present in aneurysms treated with porous ePTFE stent-grafts than Dacron grafts. Histology and MRI suggest transudation of serous blood components into aneurysm sacs treated with ePTFE stent-grafts that may contribute to increased intra-aneurysmal pressure. This transudation of serous blood components may explain the clinical finding of expansion of the aneurysm sac in the absence of an endoleak after treatment with ePTFE stent-grafts. These findings provide a mechanism for the findings observed clinically, reflecting properties of the original Excluder. However, further studies will be necessary to completely characterize the clinical significance of this endotension.

AUTHOR CONTRIBUTIONS

Conception and design: PLF, SMT, RD, JB, VF, KCK, MLM
Analysis and interpretation: PLF, SMT, RAC, SCL, BGD, EJR, RLH, MRP
Data collection: RD, SMT, MJP
Writing the article: SMT, PLF, RAC, RD, EJR, MJP, SCL
Critical revision of the article: PLF, SMT, BGD, RLH, MJP, MRP, JB, MLM, VF, KCK
Final approval of the article: SMT, RD, RAC, SCL, BGD, EJR, RLH, MJB, MRP, JB, MLM, VF, KCK, PLF
Statistical analysis: PLF, SMT, MJP
Obtained funding: PLF, KCK
Overall responsibility: PLF

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